DOCUMENT RESUME

ED 186 126 PS 011 413

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TITLE Cross-Classification Approaches to the Study of Developmental Relationships.
PUB DATE Apr 80
NOTE 10p.; Paper presented at the Biennial Southeastern Conference on Human Development (6th, Alexandria, VA, April 17-19, 1980).

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Behavior Patterns; *Classification; *Correlation; Development; Models; *Statistical Analysis; *Tables (Data)
IDENTIFIERS *Cross Classification Approaches

ABSTRACT

The richness of the information available in cross-classification tables, compared to the information conveyed in the typical correlation coefficient, is emphasized in this paper. The kinds of information to be found in cross-classification tables are described, and several examples of the use of cross-classification patterns in research are provided. Model fitting procedures for determining which of several patterns makes the best fit to a set of data are briefly illustrated. It is argued that analyses based on the identification of specific patterns in the distribution of observations in cross-classification tables provide more information about developmental relationships between tasks than analyses based on the computation of simple measures of statistical association. (Author/MP)

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Cross-Classification Approaches to the Study of Developmental Relationships

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Paper presented at the meetings of the Southeastern Conference on Human Development. Alexandria, Virginia, April 1980.

PS011413

Abstract

The chief argument of this paper was that analyses based on the identification of specific patterns in the distribution of observations in cross-classification tables provide much more information about developmental relationships between tasks than analyses based on the computation of simple measures of statistical association. The kinds of information to be found in cross-classification tables were described. Several examples of the use of cross-classification patterns in research were provided. Model fitting procedures for determining which of several patterns makes the best fit to a set of data were briefly illustrated.

The purposes of this paper are: (1) to describe the kinds of information to be found in cross-classification tables, (2) to provide research examples of the use of cross-classification approaches to developmental problems, and (3) to mention briefly two model fitting procedures for use with cross-classification data.

The richness of the information in cross-classification tables, compared to the information conveyed in the typical correlation coefficient, is illustrated with respect to Tables 1 - 3 below. The value of Kendall's Tau_b for Table 1 is .68, for Table 2 is .70, and for Table 3 is .29. Inspection of the three tables, however, reveals structural differences in the distribution of observations that cannot be effectively captured by the correlation coefficients.

Table 1. Class inclusion-Length (A) vs. Class inclusion-Volume (B)

		Task B		
		I	II	III
Task A	I	42	5	1
	II	4	9	12
	III	2	8	18

Table 2. Free Classification (A) vs. Provoked Classification (B)

		Task B		
		I	II	III
Task A	I	16	12	0
	II	0	30	9
	III	0	0	5

Table 3. Cognitive Synthesis (A) vs. Conservation (B)

		Task B		
		I	II	III
Task A	I	9	2	1
	II	11	0	3
	III	21	17	18

Table 1 is an example of a reciprocal interaction pattern, Table 2 an example of a convergent decalage pattern, and Table 3 an example of a divergent decalage pattern (Wohlwill, 1973; Jamison, 1977). According to Wohlwill, the reciprocal interaction pattern is characteristic of tasks which are developmentally interdependent. This intertask constraint is reflected in the small number of individuals in Table 1 who scored at Level III on the task and Level I on the other. The divergent decalage pattern is characteristic of tasks that are mastered sequentially. This property can be seen in Table 3 where only a small number of individuals have progressed farther on Task B than on Task A. The convergent decalage

pattern encorporates features of both the divergent dacalage and the reciprocal interaction pattern. As can be seen in Table 2, the convergent decalage pattern is like the divergent decalage pattern in that individuals have progressed farther on one task than the other, but also like the reciprocal interaction pattern in that no one has reached Level III on one task while remaining at Level I on the other. The chief feature distinguishing the three cross-classification patterns has to do with their predictions about which cells in a cross-classification table should contain no observations. In Table 1, 2, and 3 the cells with underlined frequencies are those which should contain no observations according to the pattern identified with the table.

Three examples will serve to illustrate the use of these cross-classification patterns in research. The first is taken from research on Piaget's concept of structure d'ensemble (Jamison, 1977). One variant of the structure hypothesis suggests that tasks belonging to the same grouping (e.g., all seriation tasks or all class inclusion tasks) ought to develop more or less synchronously (Flavell & Wohlwill, 1969). One very plausible definition of "more or less synchronously" is that the cross-classification tables for pairs of tasks like those shown in Table 1 should be adequately described by the reciprocal interaction pattern.

Horizontal decalage relationships can also be defined in terms of cross-classification patterns. The convergent dacalage pattern does provide an explicit model of the expectations associated with the horizontal decalage concept. On this basis, the difference in performance between free and provoked classification found by Dansky and Silverman (1977)

might be described as a horizontal decalage since their data in Table 2 do conform to the convergent decalage pattern. However, not every instance where performance differences exist between two tasks supposedly based on the same underlying concept will be horizontal decalage (i.e., will conform to the convergent decalage pattern). Some of these will be better described by the divergent decalage pattern (e.g., conservation of quantity versus conservation of weight). It would be inappropriate to describe these cases as horizontal decalages. The distinction between convergent decalage patterns and divergent decalage patterns is an important one for inferring the structural basis of intertask relations.

The third example illustrates the use of the divergent decalage pattern in identifying developmental prerequisites of cognitive acquisitions. If one task is hypothesized to be a prerequisite for another, then development on the second task should be delayed until development on the proposed prerequisite has reached some minimum level. This essential characteristic of the prerequisite relationship is nicely embodied in the divergent decalage pattern. Jamison and Dansky (1979) used this property of the divergent decalage pattern to test the hypothesis that cognitive synthesis (Farnham-Diggory & Bermon, 1968) is a prerequisite for conservation acquisition. The cross-classification results for synthesis and conservation are shown in Table 3 where it can be seen that synthesizing ability emerged earlier than conservation ability in conformity with the divergent decalage model.

In practice, of course, the best fitting pattern cannot always be identified by inspection. It is necessary to quantify the comparison

among patterns to determine which one among several candidates makes the best fit to the cross-classification table data. Thomas (1977) proposed a chi-square goodness of fit test procedure for evaluating the fit of a pattern; in comparing patterns the one with the smallest associated chi-square would be the best fit to the data. The application of Thomas' procedure is illustrated using the data in Tables 1-3. The X^2 values and associated probabilities for the fits of the reciprocal interaction, convergent decalage, and divergent decalage patterns to each of the data tables are listed in Table 4.

Table 4 Results of Goodness-of-Fit Tests

Data	Model	X^2	df	p
Table 1	Reciprocal	1.24	3	<.50
	Convergent	9.85	4	<.05
	Divergent	14.10	4	<.01
Table 2	Reciprocal	17.89	3	<.01
	Convergent	2.28	4	<.50
	Divergent	10.03	4	<.04
Table 3	Reciprocal	32.13	3	<.01
	Convergent	35.82	4	<.01
	Divergent	3.99	4	<.30

Froman and Hubert (1980) have suggested a different means of quantifying the fit of a particular pattern to a set of cross-classification data. Their method, an application of prediction analysis, requires the computation of the ratio of the number of observations found in cells where none should be found according to a pattern hypothesis (e.g., according to the reciprocal interaction pattern neither of the off-diagonal corner

cells should contain any observations) to the number of observations expected given the marginal distributions and an assumption of statistical independence. The best fitting pattern, then, is the one associated with the smallest ratio. To illustrate, the ratios for the reciprocal interaction, divergent decalage, and the convergent decalage patterns as applied to Table 1 are .11, .45, and .33 respectively.

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